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**Description**

The present invention relates to printing a highlight color image mapped from a full-color image and, more particularly, to highlight color printing which preserves information important to the viewer.

Color images are a significant element in today's printing industry. As a result, electronic color printers and color image creation tools have been increasingly developed to obtain color images using electronic printing methods. Much color printing is performed using full color, the gamut of colors including tints and shades of the full color spectrum - reds, greens, blues and their combinations. A significant amount of color printing, however, can be performed using a highlight color. In this type of printing, only two inks are used in the printing process. These inks comprise black and a highlight color (usually red or blue). Electronic printers may be designed specifically for highlight color printing. The highlight color printer is generally faster and less expensive than the full-color printer since only two inks are processed, as opposed to the three or four inks which must be processed in order to obtain full-color images.

The gamut of full colors is a three-dimensional volume which can be represented by the double hexagonal cone 10 illustrated in Figure 1 of the accompanying drawings. In this representation, shades vary from dark to light as one moves upwards vertically. Tints vary from unsaturated grays to fullysaturated colors as one moves out radially. Hues vary as one moves angularly in the hexagonal central plane.

The gamut of colors available to a highlight printer can be represented by the two-dimensional triangle 12 illustrated in Figure 2. This is a slice from the full color double hexagonal cone of Figure 1 at the angle of the highlight hue.

Prior attempts to print a full-color image on a highlight color printer involved mapping the three-dimensional double hexagonal cone of Figure 1 to the two-dimensional triangle of Figure 2. The printer makes its best effort to render the highlight color image by mapping the full color specification into the set of colors which it can produce. In such a mapping, many different colors in the full-color space will be mapped to the same color in the highlight color space. Information important to the viewer is often lost.

US-A-4,903,048 discloses color imaging using ink pattern designs in conjunction with registered two-color imaging to form simulated color images. A printing apparatus is described which is used to perform the two-color imaging.

US-A-4,554,241 discloses a method of printing a realistic image of an original on a sheet. Two printing plates are used to print different impressions with two different coloring media.

US-A-4,636,839 discloses a method and apparatus for generating color matte signals. RGB color components are calculated from hue, saturation and luminance value inputs. A new luminance value Y and color difference components CR and CB are calculated from these RGB values. Various algorithms are disclosed which are used for color calculation.

US-A-4,670,780 discloses a method for matching hard copy colors to display colors for registered ink jet copiers. A color transformation for matching hard copy color to display color consists of an MSW color space which restricts the hard copy color to certain percentages of binary mixtures of inks (M), single inks (S) and paper white (W). Color data in XYZ are converted to the MSW space, and unreachable display colors are matched into reachable hard copy colors. Corrections for color shifts because of interactions of the inks are also disclosed.

US-A-4,761,669 discloses an electrophotographic highlight color printing machine in which printing is done in at least two different colors. Methods for transferring multiple color images simultaneously are disclosed.

US-A-4,682,186 discloses a method for forming a color image by using a plurality of coloring materials and controlling quantities of the coloring materials. When a density to be reproduced exceeds the density reproducible for that coloring material, the quantities of other coloring materials are reduced.

US-A-4,907,078 discloses a method of reproducing color images wherein two charge-coupled devices of different wavelengths are used to scan a full-color document. The outputs of the charge-coupled devices are fed into a lookup table to determine the appropriate color in a two-color system. The output from the table is then recorded on a piece of paper. The system can be used for any type of copier.

US-A-4,894,665 discloses a method of generating an expanded color set of a low resolution color printer wherein a four-color printer can be expanded to twelve colors by printing a black dot next to a line to make the line seem darker. Two algorithms are provided for determining whether or not a line is critical and for enhancing a line.

US-A-4,908,779 discloses a display pattern processing apparatus wherein a system can be programmed to convert a full-color image into a number of other formats. An example is shown wherein an RGB image is converted into a two-color image.

While the related art attempts to map a full-color image to a highlight color image, it does not recognize that certain information from the full-color image should be preserved, depending upon how the color is being used and what type of image is being created. Accordingly, information is lost in these devices.

Accordingly the present invention provides a mapping of full color images to highlight color images in which information important to the viewer is preserved. The fully-saturated color for any given hue in the full-color image is mapped to the apex of a color triangle, the position of the apex varying according to hue, and the apex being at some point within a triangle of printable colors. The set of the apex points for different hues describes the set of highlight colors generated by the mapping of fully-saturated colors. For an arbitrary highlight hue, the fully saturated colors slide around

a locus curve until the hue of the highlight color is mapped to the right-most apex of the highlight gamut triangle. In creating pictorial images, the mapping is performed such that there is no more highlight color in the mapped image than is present in the original full color image.

The basic inventive concept is claimed in independent claims 1,5,6,9,13 and 14.

The invention will be described by way of example with reference to the accompanying drawings, in which like reference numerals refer to like elements and wherein:

Figure 1 illustrates a three-dimensional full-color space;
Figure 2 illustrates a two-dimensional triangle of colors available to a highlight printer;
Figure 3 illustrates a two-dimensional triangle of colors printable by a highlight color printer for any given hue;
Figure 4 illustrates a locus of mapping fully-saturated colors;
Figure 5 illustrates an alternative locus of fully-saturated colors especially useful for pictorial images;
Figure 6 illustrates an alternative locus of fully-saturated colors especially useful for both pictorial and presentation graphics;
Figure 7 illustrates a locus of fully-saturated colors especially useful for presentation graphics images for an arbitrary highlight color;
Figure 8 illustrates a hexagon of fully-saturated colors;
Figure 9 illustrates a locus of fully saturated colors especially useful for pictorial images for an arbitrary highlight color, and
Figure 10 is a block diagram of a device for mapping a full color image to a highlight color image.

Referring now to the drawings, and particularly to Figure 3 thereof, the mapping of full-color images to highlight color images is described. Triangle 14 defines the highlight color space comprising the different colors available to a highlight printer. Triangle 14 has an apex 16 corresponding to the fully-saturated hue of the highlight color. Points 18 and 20 define the amounts of white and black, respectively, available to a highlight color printer.

To preserve information desirable in both presentation graphics and pictorial image applications, it is desirable to derive diverse colors for fully-saturated hues in the full-color image while still preserving the basic luminance and saturation behavior. For any given hue, the triangle of possible colors 14 will be mapped to a triangle of printable colors 22. The fully-saturated color for the given hue maps to the apex 24 of the result color triangle 22. The position of apex 24 varies according to hue. If the hue matches that of highlight color, the apex 24 of the result color triangle 22 will coincide with the apex 16 of the triangle of possible colors 14, and the mapping will be the identity. For other hues, the apex 24 will be at some point within the triangle 14 of possible colors. The set of the apex points for different hues defines the set of highlight colors generated by the mapping of fully-saturated colors.

The information which should be preserved depends upon how the color is being used. For pictorial images, most of the information lies in the luminance. For this reason, black and white photographs are easily recognizable. The hue in pictorial images is of secondary importance. For example, it is desirable to view a color image in which the sky is blue, the grass is green and faces are of flesh tones.

When color is used to highlight an image, the information derived is from the presence or absence of color rather than a gray level. A colored area with the same luminance as a gray area should look different. Highlight color documents may also vary in saturation.

In presentation graphics such as graphs and charts, by contrast, most of the information is in the hue. In this application, one usually selects strongly saturated colors for impact, using hue to differentiate them. An example of a mapping particularly applicable to presentation graphics is now described. In this example, red is used as the highlight color of the printer. The red, green and blue coordinates (r, g and b) of the full color image are determined. Each coordinate ranges between 0 and 1, with 0 meaning no color (black) and 1 meaning full color. Once the respective amounts of the red, green and blue coordinates of the full color image are determined, the resulting highlight color image can be determined by specifying the amounts of highlight color (h), white (w) and black (k) in the highlight color image in accordance with:

$$h = (3\ \mathrm{MAX}(r,g,b) + r - \mathrm{MAX}(g,b) - 3\ \mathrm{MIN}(r,g,b))/4$$

$$w = (g - b + \mathrm{MAX}(g,b) - \mathrm{MIN}(r,g))/4 + \mathrm{MIN}(r,g,b)$$

$$k = 1 - h - w.$$

The function MAX returns the maximum of its arguments, and the function MIN returns the minimum of its arguments.

Figure 4 illustrates the locus of mapping fully-saturated colors as set forth in the above example. The arrows define the path of the apex corresponding to fully-saturated colors for given hues. In this mapping, every mapped fully-saturated color is unique. Excellent results are achieved for presentation graphics applications. Any non-gray color is mapped to a non-gray result, and lightness saturation behavior is preserved. This provides very good results for highlight color applications.

As discussed above, it is important to preserve luminance in pictorial applications. While the above example preserves the relative lightness behavior, it is not as effective in preserving luminance. Luminance accounts for white and black, but luminance also includes the eye's sensitivity to different hues (for example, blue looks darker than yellow). While a picture is quite recognizable, dark hues such as blue may be mapped to lighter colors than light hues such as yellow. Even more significant are some unpleasant color shifts. As an example, when blue highlight color is used, unnatural blue flesh tones can be obtained in a mapped highlight color image.

An example of a mapping better suited for pictorial images using a red highlight color is herein described. Using this type of mapping, the luminance of the original image is preserved. In addition, there is never more highlight color present in the resultant highlight color image than the amount of that hue present in the original full-color image. The luminance of the original full color image depends on the basic colors of the rgb color coordinates, but can be approximated by:

$$y = 1/4r + 2/3g + 1/12b$$

wherein r, g and b are the respective amounts of the red, green and blue coordinates in the full-color image. A resulting mapped highlight color image is determined by establishing highlight color (h), white (w) and black (k) in accordance with:

$$h = \mathrm{MIN}(4(\mathrm{MAX}(r,g,b)-y)/3,\ 4(y-\mathrm{MIN}(r,g,b)),$$

$$r - \mathrm{MIN}(r,g,b))$$

$$w = y-h/4$$

$$k = 1-h-w.$$

The function MAX returns the maximum of its arguments and the function MIN returns the minimum of its arguments.

Figure 5 illustrates the locus of fully-saturated colors using this mapping particularly applicable to pictorial images.

A slight variation in this mapping can be used to also improve the behavior of presentation graphics. As indicated above, this mapping would also preserve the luminance and restrict the amount of highlight color to no more than is present in the original full-color image. In addition, however, further small reductions can be made in the amount of highlight color as a function of hue in order to disambiguate fully-saturated colors which would otherwise be indistinguishable.

For this mapping, also using red as the highlight color, the following two constraints are added to the determination of the resulting mapped highlight color image:

$$h \le (\mathrm{MAX}\ (r,g,b) + r-b-\mathrm{MIN}(r,g,b))/2$$

$$h \le (\mathrm{MAX}\ (r,g,b) - (8g + \mathrm{MIN}(r,g,b))/9$$

Accordingly, the highlight color coördinate (h) of the resulting mapped highlight color image becomes:

$$h = \mathrm{MIN}(4(\mathrm{MAX}(r,g,b)-y)/3,4(y-\mathrm{MIN}(r,g,b)),$$

$$r- \mathrm{MIN}(r,g,b),(\mathrm{MAX}(r,g,b) + r-b-\mathrm{MIN}(r,g,b))/2,$$

$$\mathrm{MAX}(r,g,b) - (8g + \mathrm{MIN}(r,g,b))/9).$$

Figure 6 illustrates the locus of fully-saturated colors for the above described example of mapping full color images to highlight color images particularly applicable to both pictorial images and presentation graphics. Improved behavior is achieved in colors which mapped to the same result in the previous example. The removal of ambiguities enables fully-saturated colors in the mapped image to be further distinguished while preserving luminance and restricting the amount of highlight color to no more than is present in the original full-color image.

While the above-described mappings are used to map full-color images to red highlight color images, the mappings can be generalized to enable mapping from full-color images to arbitrary highlight color images, not just red highlight color images. Mapping to arbitrary highlight color images also preserves the general luminance and saturation behavior and maps fully-saturated colors to a continuous, unique collection of highlight colors.

Figure 7 illustrates the locus of fully-saturated colors especially for an arbitrary highlight hue. To generalize to the arbitrary highlight hue, the fully-saturated colors are slid around the locus triangle of Figure 7 until the hue at the right-most apex of thetriangle corresponds to that of the arbitrary highlight color.

An operation for the reorientation of saturated colors can be carried out by a simple computer algorithm based on the definition of hue proposed by A. R. Smith in "Color Gamut Transform Pairs", Computer Graphics, Vol. 12, No. 3, pp. 12-19 (1978). A hue value in the range [0,6] is determined by adding a number based on which of the r, g, b components is largest, to an offset based on the relative strength of the second largest component. Under this definition, red (1,0,0) has hue 0, green (0,1,0) has hue 2 and blue (0,0, 1) has hue 4. The secondary colors yellow, cyan, and magenta have values 1, 3, and 5 respectively.

The algorithm uses a hue difference equal to the hue of a sample color minus the hue of the highlight color. A hue difference of 0 indicates that the sample color matches the hue of the highlight color. If the sample color is fully saturated (at least one of its r, g, b components is 1 and at least one is 0) and the sample matches the highlight hue, then it will be mapped to the right-most apex of the triangle in highlight space. Following around the hexagon of fully-saturated colors shown in Figure 8 from the highlight color gives an increasing hue difference from 0 to 6, corresponding to the desired slide of the saturated colors around the locus triangle. Assuming a fixed sample (r, g, b), there is a corresponding fully-saturated color x and its hue difference, a corresponding point on the locus triangle ($h_x w_x$) and thus a triangle into which the sample must be mapped.

The mapped result for a sample color (r, g, b) depends upon: the amount of white in the sample, given by the minimum component m = MIN(r,g,b); the amount of color in the sample, given by the difference d = MAX(r,g,b)-m; and the position of the apex point in highlight-white coordinates ($h_x$, $w_x$). The amount of highlight is the amount of color scaled by the highlight component of the apex, $h = d\ h_x$. The amount of white is the amount of white in the sample plus a term for the white shift of the apex, $w = m + d\ w_x$.

The implementation takes the form of nested conditionals yielding six cases corresponding to the six possible orderings of relative strengths of the three color components. One can determine the hue for a sample color and subtract from it the hue of the highlight color. The resulting difference can then be used to determine the point of the fully-saturated color. The value 0 always corresponds to the right-most apex of the triangle. The implementation calculates the variable hdiff which is the hue difference multiplied by the amount of chrominance d, since this is what is ultimately needed, and combining the computations avoids a division. Finally, the amount of highlight color and white (or black) can be determined from the amount of chrominance and white in the original sample and the position of the corresponding fully-saturated color. A program fragment written in the C programming language which does this is:

```
/* given r,g,b as the coordinates of the sample color */
/* compute h, w, the amount of highlight and white */
/* hlhue comes from the hue of the highlight color */
/* n gives the triangle size */
/* find sample's white, chrominance, and weighted hue difference */
if (r > g)
{if (g > b) /* case r > g > b */
 {m = b; d = r - b; hdiff = (1 - hlhue)*d - r + g;}
 else
 {if (r> b) /* case r > b >= g*/
  {m = g; d = r - g; hdiff = (5 - hlhue)* d + r - b;}
else /* case b >= r > g*/
 {m = g; d = b - g; hdiff = (5 - hlhue)* d - b + r;}
 }}
 else
 {if (r > b) /* case g >= r > b*/
  {m = b; d = g - b; hdiff = (1 - hlhue)*d + g - r;}
  else
  {if (g > b) /* case g > b >= r*/
  {m = r; d = g - r; hdiff = (3 - hlhue)*d - g + b;}
  else /* case b >= g > r */
  {m = r; d = b - r; hdiff = (3 - hlhue)*d + b - g;}
}}
if (hdiff < 0)
 hdiff = hdiff + 6*d;

/* determine highlight and white result */

        if (hdiff < 2*d) /* map to top of locus triangle */
        {h = d - n*hdiff/2; w = d - h + m;}
        else
        {if (hdiff < 4*d) /* map to left of locus triangle */
         {h = ( 1 - n)*d; w = n*(2*d - hdiff/2) + m;}
         else /* map to bottom of locus triangle */
         {h = (1 - 3*n)*d + hdiff*n/2; w = m;}
```

The program makes use of the variable hlhue which is derived from the highlight color as indicated below:

```
/* given the coördinates for the highlight color hlr, hlg, hlb */
/* calculate its corresponding hue parameter hlhue */

if (hlr > hlg)
{if (hlg > hlb) hlhue = 1 - (hlr - hlg)/(hlr - hlb);
 else
  {if (hlr > hlb) hlhue = 5 + (hlr - hlb)/(hlr - hlg);
  else hlhue = 5 - (hlb - hlr)/(hlb - hlg);
}}
else
{if (hlr > hlb) hlhue = 1 + (hlg - hlr)/(hlg - hlb);
 else
  {if (hlg > hlb) hlhue = 3 - (hlg - hlb)/(hlg - hlr);
  else hlhue = 3 + (hlb - hlg)/(hlb - hlr);
}}
```

The program also contains a scale factor n which determines the size of the triangle formed by the locus of saturated colors. To replicate the simple mapping given in the first example for red highlight, one would use hlhue = 0 and n = 0.5. Experiments with various other highlight hues indicate that the value n = 0.5 may actually be smaller than the optimum. Increasing this value increases the differentiation of the saturated colors at the expense of colors available for the mapping of the unsaturated colors. A value of n = 0.75 gives better results. Note that a value of n = 1 would map the locus of saturated colors to the boundary of producible colors. This would give maximum differentiation of the saturated colors, but would map a third of all color space into gray.

Once the highlight color is known, the value of hlhue can be computed. This result and the desired size parameter n, when known, can be used to simplify some of the indicated arithmetic in the program fragment defined above. This should be done to reduce the amount of calculation required for mapping an individual color.

Note that some assumptions have been made to simplify this mapping. It is assumed that the sample colors have coordinates in the range [0,1] and no provisions have been made for out-of-gamut colors. Also, in order for the samples that match the highlight color to pass through this mapping unchanged, the highlight color must lie on the gamut boundary.

The above-described mapping is particularly effective for presentation graphics. It preserves the relative lightness behavior but does not completely preserve luminance. All saturated colors are mapped to different non-neutral colors in the highlight color plane. The mapping differentiates colors as well as indicates that the areas were colored in the original full color image.

Full-color pictorial images can be mapped into arbitrary highlight colors while preserving luminance and including no more of the highlight color than was present in the full color image. To achieve this, however, one must define how much of one color is present in another color. One way this can be achieved is by expressing colors in the original full-color image and in the highlight color in the YES coordinate system. In this coordinate system, Y is the luminance and E and S are the chrominance components. The E coordinate is the red-green scale, and the S coordinate is the yellow-blue scale. Using this coördinate system, the measure of color similarity is based on the chrominance components. The Y, E and S are determined in accordance with:

$$Y = 0.253r + 0.684g + 0.063b;$$

$$E = (r - g)/2; \text{ and}$$

$$S = (r + g)/4 - b/2$$

Each of these coördinates is determined for the highlight color and sample color of the full-color image.

The cube of the cosine function is used to measure the similarity of colors by determining the cosine of the angle between chrominance vectors. This cosine measure gives 1 when the colors are aligned, and reduces to 0 when the vectors are at right angles. It is easily calculated from the dot product of the vectors. The cosine measure gives the projection of one color onto another. The YES coordinates of the highlight color $Y_hE_hS_h$, and the YES coordinates of the sample color $Y_sE_sS_s$, are used to obtain the following cosine cubed mapping to highlight and white amounts h and w, respectively:

$$h = MAX(0,(E_hE_s + S_hS_s)^3/((E_s^2 + S_s^2)(E_h^2 + S_h^2)^2))$$

$$w = MIN(1 - h, Y_s - hY_h)$$

$$k = 1 - h - w.$$

Figure 9 illustrates the locus of fully-saturated colors for a red highlight color obtained using the mapping.

The above-described mapping of pictorial images preserves the luminance, while ensuring that there is no more highlight color in the mapped image than is present in the full color image and while generating natural looking pictorial images.

Figure 10 is a block diagram of a printer 100 which maps full-color images to highlight color images. Printer 100 contains a computer 110 which determines the coordinates required for the above-described image mappings. Once these coordinates are determined, computer 110 controls printer 100 to generate the mapped images. A printing apparatus, such as that described in US-A-4,903,048 can be used to accomplish the mapping operation of the present invention.

The mappings from full-color to highlight color as described above provide excellent results for both pictorial image and presentation graphics applications. The shades and tints for each hue are mapped to a corresponding triangle of colors in the plane of the highlight hue. The apex of the triangle of result colors is varied within the triangle of possible result colors according to hue. Differentiations are provided in the result color for the fully-saturated cases while preserving relative saturation and lightness behavior. The triangle of result colors can exactly match the triangle of possible colors when the original hue matches the highlight hue, thereby specifying highlight colors in a manner consistent with full-color specifications.

Simple mappings based on maximum and minimum functions are provided when the highlight color used is red. More general mappings are further provided which are used for arbitrary highlight colors.

Just as several illustrative mappings were presented, many are possible giving different tradeoffs of image quality, ease of calculation, generality and information preserved. Thus, the exemplary mappings do not exclude alternative mappings which preserve lightness and saturation behavior by mapping the colors of a given hue to a triangle of colors within the highlight gamut.

## Claims

1. A method of mapping a full-color image to a highlight color image producible by a highlight color printer (100) which can print in only two colors, comprising the steps of:

   defining a substantially planar triangular color space (14) comprising a complete set of possible colors available to the highlight color printer, the triangular color space having a base (w) defined between two points (18,20), representing no color and a fully saturated first highlight color, and an apex (16) corresponding to a fully saturated second highlight color (h) of the highlight color printer;

   determining, within the triangular color space, a location (24) of a fully-saturated color for any given hue in the full-color image; and

   mapping a color space for the given hue to a triangle (22) of printable colors by the highlight color printer, the triangle of printable colors being a subset of the triangular color space and having its apex (24) coinciding with the location of the fully-saturated color of the given hue.

**2.** The method as claimed in claim 1, further comprising the steps of:

selecting black as the first highlight color;
selecting red as the second highlight color; and
mapping to the triangle of printable colors by:

a) determining the respective amounts of the red, green and blue coordinates (r, g, b) in the full-color image, each coordinate ranging between 0 and 1, and
b) determining a resulting highlight color image by specifying the amounts of highlight color (h), white (w) and black (k) in the highlight color image in accordance with:

$$h = (3\,\mathrm{MAX}(r,g,b) + r - \mathrm{MAX}(g,b)\ 3\,\mathrm{MIN}(r,g,b))/4$$

$$w = (g - b + \mathrm{MAX}(g,b) - \mathrm{MIN}(r,g))/4 + \mathrm{MIN}(r,g,b)$$

$$k = 1 - h - w.$$

**3.** The method as claimed in claim 1, further comprising the steps of:

preserving the luminance of the full-color image in the mapped image, wherein the luminance (y) is determined by:

$$y = 1/4r + 2/3g + 1/12b;$$

the preserving step including mapping to the triangle of printable colors by:

a) determining the respective amounts of the red, green and blue coöordinates (r,g,b) in the full-color image, each coördinate ranging between 0 and 1, and
b) determining a resulting mapped highlight color image by determining highlight color (h), white (w) and black (k) in accordance with:

$$h = \mathrm{MIN}(4(\mathrm{MAX}(r,g,b)-y)/3,\ 4(y-\mathrm{MIN}(r,g,b)), r-\mathrm{MIN}(r,g,b))$$

$$w = y - h/4$$

$$k = 1 - h - w.$$

**4.** The method as claimed in claim 3, further comprising the step of:
distinguishing fully-saturated colors in the mapped image by determining the resulting mapped highlight color image by determining h in accordance with:

$$h = \mathrm{MIN}(4(\mathrm{MAX}(r,g,b)-y)/3,\ 4(y-\mathrm{MIN}(r,g,b)),$$

$$r-\mathrm{MIN}(r,g,b),\ (\mathrm{MAX}(r,g,b) + r-b-\mathrm{MIN}(r,g,b))/2,$$

$$\mathrm{MAX}(r,g,b) - (8g + \mathrm{MIN}(r,g,b))/9).$$

**5.** A method of mapping a full-color image to an arbitrary highlight color image producible by a highlight color printer which can print in only two colors, comprising the steps of:

defining a substantially-planar triangular color space comprising a complete set of possible colors for a highlight color printer, the triangular color space having a base (w) defined between two points (18,20), representing

no color and a fully saturated first highlight color, and an apex (16) corresponding to a fully saturated second highlight color (h) of the highlight color printer;
defining, in the color space, a locus curve of fully-saturated colors;
identifying the hue of the highlight color of the printer;
sliding the fully-saturated colors around the locus curve until the hue at an extreme point of the curve relative to the white/black axis corresponds to the hue of the highlight color, and
mapping the color space into a triangle of printable colors by the highlight color printer for a given hue, the triangle being a subset of the color space and having its apex coinciding with the location of a fully-saturated color of the given hue.

6. A method of mapping a full-color image to a highlight color image producible by a highlight color printer which can print in only two colors, comprising the steps of:

expressing the highlight color and a given color of the full-color image in color coordinates of a YES color coordinate system determined by the following formulas:
Y (luminance) = 0.253r + 0.684g + 0.063b;
E (chrominance component red-green scale) = (r - g)/2;
S (chrominance component yellow-blue scale) = (r + 9)/4 - b/2; and
using the color coordinates of the highlight color ($Y_hE_hS_h$) and the given color ($Y_sE_sS_s$) to map the full-color image to a highlight color image;
wherein pictorial images are generated such that there is no more highlight color in the mapped image than is present in the full-color image.

7. The method as claimed in claim 6, further comprising the steps of:
determining the respective amounts of the red, green and blue coördinates (r, g, b) in the highlight color and the given color, each coordinate ranging between 0 and 1.

8. The method as claimed in claim 7, further comprising the step of:
mapping the full-color image to the highlight color image by specifying the amounts of highlight color (h), white (w) and black (k) in the highlight color image in accordance with:

$$h = \mathrm{MAX}(0,(E_hE_s + S_hS_s)^3/((E_s^2 + S_s^2)(E_h^2 + S_h^2)^2))$$

$$w = \mathrm{MIN}(1 - h, Y_s - hY_h)$$

$$k = 1 - h - w.$$

9. Apparatus for mapping a full-color image to a highlight color image producible by a highlight color printer which can print in only two colors, comprising:

means for defining a substantially-planar triangular color space comprising a complete set of possible colors for a highlight color printer, the triangular color space having a base (w) defined between two points (18,20), representing no color and a fully saturated first highlight color, and an apex (16) corresponding to a fully saturated second highlight color (h) of the highlight color printer;
means for determining within the triangular color space the location of a fully-saturated color for any given hue in the full-color image, and
means for mapping the color space for the given hue to a triangle of printable colors by the highlight color printer, the triangle being a subset of the color space and having its apex coinciding with the location of the fully-saturated color of the given hue.

10. The apparatus as claimed in claim 9, further comprising:

means for specifying red as the highlight color; and
the mapping means including:

a) means for determining the respective amounts of the red, green and blue coördinates (r, g, b) in the full-color image, each coördinate ranging between 0 and 1; and

b) means for determining a resulting highlight color image by specifying the amounts of highlight color (h), white (w) and black (k) in the highlight color image in accordance with:

$$h = (3\,MAX(r,g,b) + r - MAX(g,b) - 3\,MIN(r,g,b))/4$$

$$w = (g - b + MAX(g,b) - MIN(r,g))/4 + MIN(r,g,b)$$

$$k = 1 - h - w.$$

**11.** The apparatus as claimed in claim 9, further comprising:

means for preserving the luminance of the full-color image in the mapped image, wherein the luminance (y) is determined by:

$$y = 1/4r + 2/3g + 1/12b;$$

the preserving means including:

a) means for determining the respective amounts of the red, green and blue coördinates (r,g,b) in the full color image, each coördinate ranging between 0 and 1; and
b) means for determining a resulting mapped highlight color image by determining highlight color (h), white (w) and black (k) in accordance with:

$$h = MIN(4(MAX(r,g,b)-y)/3,\ 4(y-MIN(r,g,b)), r-MIN(r,g,b))$$

$$w = y - h/4$$

$$k = 1 - h - w.$$

**12.** The apparatus as claimed in claim 11, further comprising:
means for distinguishing fully-saturated colors in the mapped image by determining the resulting mapped highlight color image by determining h in accordance with:

$$h = MIN(4(MAX(r,g,b)-y)/3,\ 4(y-MIN(r,g,b)),$$

$$r-MIN(r,g,b),\ (MAX(r,g,b) + r-b-MIN(r,g,b))/2,$$

$$MAX(r,g,b) - (8g + MIN(r,g,b))/9).$$

**13.** Apparatus for mapping a full color image to an arbitrary highlight color image producible by a highlight color printer which can print in only two colors, comprising:

first means for defining a substantially planar triangular color space comprising a complete set of possible colors for a highlight color printer, the triangular color space having a base (w) defined between two points (18,20), representing no color and a fully saturated first highlight color, and an apex (16) corresponding to a fully saturated second highlight color (h) of the highlight color printer;
second means for defining, in the color space, a locus curve of fully-saturated colors;
means for identifying the hue of the highlight color of the printer;
means for sliding the fully-saturated colors around the locus curve until the hue at an extreme point of the curve remote from the black/white axis corresponds to the hue of the highlight color, and
means for mapping the color space for a given hue into a triangle of printable colors by the highlight color printer, the triangle being a subset of the color space and having its apex coinciding with the location of a fully-saturated color of the given hue.

14. Apparatus for mapping a full-color image to a highlight color image producible by a highlight color printer which can print in only two colors, comprising:

means for expressing the highlight color and a given color of the full-color image in color coordinates of a YES color coordinate system determined by the following formulas:
Y (luminance) = 0.253r + 0.684g + 0.063b;
E (chrominance component red-green scale) = (r - g)/2;
S (chrominance component yellow-blue scale) = (r + g)/4 - b/2; and means for using the color coordinates of the highlight color ($Y_hE_hS_h$) and the given color ($Y_sE_sS_s$) to map the full-color image to a highlight color image; wherein pictorial images are generated such that there is no more highlight color in the mapped image than is present in the full-color image.

15. The apparatus as claimed in claim 14, further comprising:
means for determining the respective amounts of the red, green and blue coordinates (r, g, b) in the highlight color and the given color, each coördinate (r, g, b) ranging between 0 and 1.

16. The apparatus as claimed in claim 15, further comprising:
means for mapping the full-color image to the highlight color image by specifying the amounts of highlight color (h), white (w) and black (k) in the highlight color image in accordance with:

$$h = MAX(0,(E_hE_s + S_hS_s)^3/((E_s^2 + S_s^2)(E_h^2 + S_h^2)^2))$$

$$w = MIN(1 - h, Y_s - hY_h)$$

$$k = 1 - h - w.$$

## Revendications

1. Procédé pour projeter une image polychrome sous la forme d'une image à couleurs pures pouvant être produite par une imprimante (100) à couleurs pures ne pouvant imprimer que dans deux couleurs, comprenant les étapes consistant à :

définir un espace (14) des couleurs triangulaire sensiblement plan comprenant un ensemble complet de couleurs possibles disponibles à l'imprimante à couleurs pures, l'espace des couleurs triangulaire ayant une base (w) définie entre deux points (18,20), représentant l'absence de couleur et une première couleur pure totalement saturée, et un sommet (16) correspondant à une seconde couleur (h) pure totalement saturée de l'imprimante à couleurs pures ;
à déterminer, à l'intérieur de l'espace des couleurs triangulaire, une position (24) d'une couleur totalement saturée pour une teinte donnée quelconque dans l'image polychrome ; et
à projeter un espace des couleurs correspondant à une teinte donnée sur un triangle (22) de couleurs imprimables par l'imprimante à couleurs pures, le triangle de couleurs imprimables étant un sous-ensemble de l'espace des couleurs triangulaire et son sommet (24) coïncidant avec la position de la couleur totalement saturée de la teinte donnée.

2. Procédé selon la revendication 1, comprenant en outre les étapes consistant à :

sélectionner le noir comme première couleur pure ;
sélectionner le rouge comme seconde couleur pure ; et
effectuer la projection sur le triangle de couleurs imprimables :

a) en déterminant les valeurs respectives des coordonnées rouge, verte et bleue (r, g, b) dans l'image polychrome, chaque coordonnée étant comprise entre 0 et 1, et
b) en déterminant une image en couleurs pures obtenue en spécifiant les valeurs de la couleur pure (h), du blanc (w) et du noir (k) dans l'image en couleurs pures conformément à :

$$h = (3MAX(r,g,b)+r-MAX(g,b)-3MIN(r,g,b))/4$$

$$w = (g-b+MAX(g,b)-MIN(r,g))/+4MIN(r,g,b)$$

$$k = 1-h-w.$$

3. Procédé selon la revendication 1, comprenant en outre les étapes consistant à :

conserver la luminance de l'image polychrome dans l'image projetée, la luminance (y) étant déterminée par :

$$y = 1/4r+2/3g+1/12b ;$$

l'étape de conservation comprenant la projection sur le triangle des couleurs imprimables :

a) en déterminant les valeurs respectives des coordonnées rouge, verte et bleue (r,g,b) dans l'image polychrome, chaque coordonnée étant comprise entre 0 et 1, et
b) en déterminant une image en couleurs pures projetée obtenue en déterminant la couleur pure (h), le blanc (w) et le noir (k) conformément à :

$$h = MIN(4(MAX(r,g,b)-y)/3,4(y-MIN(r,g,b)),r-MIN(r,g,b)),$$

$$w = y-h/4,$$

$$k = 1-h-w.$$

4. Procédé selon la revendication 3, comprenant en outre l'étape consistant :
à distinguer les couleurs totalement saturées dans l'image projetée par détermination de l'image en couleurs pures projetée qui en résulte en déterminant h conformément à :

$$h = MIN(4(MAX(r,g,b)-y)/3,4(y-MIN(r,g,b)),$$

$$r-MIN(r,g,b),(MAX(r,g,b)+r-b-MIN(r,g,b))/2,$$

$$MAX(r,g,b)-(8g+MIN(r,g,b,))/9.$$

5. Procédé de projection d'une image polychrome vers une image en couleurs pures arbitraire pouvant être reproduite par une imprimante à couleurs pures ne pouvant imprimer que dans deux couleurs, comprenant les étapes consistant :

à définir un espace des couleurs triangulaire sensiblement plan comprenant un ensemble complet de couleurs possibles pour une imprimante à couleurs pures, l'espace des couleurs triangulaire ayant une base (w) définie entre deux points (18,20), représentant l'absence de couleur et une première couleur pure totalement saturée, et un sommet (16) correspondant à une seconde couleur (h) pure totalement saturée de l'imprimante à couleurs pures,
à définir dans l'espace des couleurs, une courbe de lieu des couleurs totalement saturées ;
à identifier la teinte de la couleur pure de l'imprimante,
à déplacer les couleurs totalement saturées le long de la courbe de lieu jusqu'à ce que la teinte se trouvant à un point extrême de la courbe par rapport à l'axe blanc/noir corresponde à la teinte de la couleur pure, et
à projeter l'espace des couleurs sur un triangle de couleurs imprimables par l'imprimante à couleurs pures pour une teinte donnée, le triangle étant un sous-ensemble de l'espace des couleurs et ayant un sommet qui correspond à la position d'une couleur totalement saturée de la teinte donnée.

6. Procédé de projection d'une image polychrome sous la forme d'une image à couleurs pures pouvant être produite par une imprimante à couleurs pures ne pouvant imprimer que dans deux couleurs, comprenant les étapes

consistant :

à exprimer la couleur pure et une couleur donnée de l'image polychrome dans des coordonnées de couleurs d'un système de coordonnées de couleurs YES déterminé par les formules suivantes :

$$Y \text{ (luminance)} = 0{,}253r + 0{,}684g + 0{,}063b \text{ ;}$$

$$E \text{ (échelle rouge-vert de la composante de chrominance)} = (r-g)/2 \text{ ;}$$

$$S \text{ (échelle jaune-bleu de la composante de chrominance)} = (r+g)/4 - b/2 \text{ ; et}$$

à utiliser les coordonnées de couleurs de la couleur pure ($Y_hE_hS_h$) et de la couleur donnée ($Y_sE_sS_s$) pour projeter l'image sous la forme d'une image à couleurs pures ;
dans lequel des images d'illustration sont produites de façon que la proportion de couleur pure dans l'image projetée ne soit pas supérieure à celle qui est présente dans l'image polychrome.

**7.** Procédé selon la revendication 6, comprenant en outre les étapes consistant :
à déterminer les valeurs respectives des coordonnées rouge, verte et bleue (r,g,b) dans la couleur pure et la couleur donnée, chaque coordonnée étant comprise entre 0 et 1.

**8.** Procédé selon la revendication 7, comprenant en outre les étapes consistant à :
projeter l'image polychrome sous la forme de l'image en couleurs pures, en spécifiant les valeurs de la couleur pure (h), du blanc (w) et du noir (k) dans l'image en couleurs pures conformément à :

$$h = \mathrm{MAX}\,(0, (E_hE_s+S_hS_s)^3/((E_s^2+S_s^2)(E_h^2+S_h^2)^2))$$

$$w = \mathrm{MIN}(1-h, Y_s-hY_h)$$

$$k = 1-h-w.$$

**9.** Appareil pour projeter une image polychrome sous la forme d'une image en couleurs pures pouvant être produite par une imprimante à couleurs pures qui ne peut imprimer que dans deux couleurs, comprenant :

des moyens pour définir un espace des couleurs triangulaire sensiblement plan comprenant un ensemble complet de couleurs possibles pour une imprimante à couleurs pures, l'espace des couleurs triangulaire ayant une base (w) définie entre deux points (18,20), représentant l'absence de couleurs et une première couleur pure totalement saturée, et un sommet (16) correspondant à une seconde couleur (h) pure totalement saturée de l'imprimante à couleurs pures ;
des moyens pour déterminer, à l'intérieur de l'espace des couleurs triangulaire, la position d'une couleur totalement saturée pour une teinte quelconque donnée dans l'image polychrome, et
des moyens pour projeter l'espace des couleurs pour la teinte donnée, sur un triangle de couleurs imprimables par l'imprimante à couleurs pures, le triangle étant un sous-ensemble de l'espace des couleurs et ayant un sommet qui coïncide avec la position de la couleur totalement saturée de la teinte donnée.

**10.** Appareil selon la revendication 9, comprenant en outre :

des moyens pour spécifier le rouge comme étant la couleur pure ; et
des moyens de projection comprenant :

a) des moyens pour déterminer les valeurs respectives des coordonnées rouge, verte et bleue (r,g,b) dans l'image polychrome, chaque coordonnée étant comprise entre 0 et 1 ; et
b) des moyens pour déterminer une image en couleurs pures obtenue en spécifiant les valeurs de la couleur pure (h), du blanc (w) et du noir (k) dans l'image en couleurs pures conformément à :

$$h = (3MAX(r,g,b)+r-MAX(g,b)-3MIN(r,g,b))/4$$

$$w = (g-b+MAX(g,b)-MIN(r,g))/4+MIN(r,g,b)$$

$$k = 1-h-w.$$

**11.** Appareil selon la revendication 9, comprenant en outre :

des moyens pour conserver la luminance de l'image polychrome dans l'image projetée, dans lesquels la luminance (y) est déterminée par :

$$y = 1/4r + 2/3g + 1/12b ;$$

des moyens de conservation comportant :

a) des moyens pour déterminer les valeurs respectives des coordonnées rouge, verte et bleue (r,g,b) dans l'image polychrome, chaque coordonnée étant comprise entre 0 et 1 ; et
b) des moyens pour déterminer une image en couleurs pures projetée obtenue en déterminant la couleur pure (h), le banc (w) et le noir (k) conformément à :

$$h = MIN(4(MAX(r,g,b)-y)/3,4(y-MIN(r,g,b)),r-MIN(r,g,b))$$

$$w = y-h/4$$

$$k = 1-h-w.$$

**12.** Appareil selon la revendication 11, comprenant en outre :
des moyens pour distinguer des couleurs totalement saturées dans l'image projetée par détermination de l'image en couleurs pures projetée obtenue en déterminant h conformément à :

$$h = MIN(4(MAX(r,g,b)-y)/3,4(y-MIN(r,g,b)),$$

$$r-MIN(r,g,b),(MAX(r,g,b)+r-bMIN(r,g,b))/2,$$

$$MAX(r,g,b)-(8g+Min(r,g,b))/9).$$

**13.** Appareil pour projeter une image polychrome sous la forme d'une image en couleurs pures arbitraire pouvant être produite par une imprimante à couleurs pures ne pouvant imprimer que dans deux couleurs, comprenant :

des premiers moyens pour définir un espace des couleurs triangulaire sensiblement plan comprenant un ensemble complet de couleurs possibles pour une imprimante à couleurs pures, l'espace triangulaire des couleurs ayant une base (w) définie entre deux points (18,20), représentant l'absence de couleur et une première couleur pure totalement saturée, et un sommet (16) correspondant à une seconde couleur (h) pure totalement saturée de l'imprimante à couleurs pures ;
des seconds moyens pour définir, dans l'espace des couleurs, une courbe de lieu de couleurs totalement saturées ;
des moyens pour identifier la teinte de la couleur pure de l'imprimante ;
des moyens pour déplacer les couleurs totalement saturées le long de la courbe de lieu jusqu'à ce que la teinte correspondant à un point extrême de la courbe qui est éloigné de l'axe noir/blanc corresponde à la teinte de la couleur pure, et
des moyens pour projeter l'espace des couleurs, pour une teinte donnée, à l'intérieur d'un triangle de couleurs imprimables par l'imprimante à couleurs pures, le triangle étant un sous-ensemble de l'espace des couleurs et ayant un sommet qui coïncide avec la position d'une couleur totalement saturée de la teinte donnée.

14. Appareil pour projeter une image polychrome sous la forme d'une image en couleurs pures pouvant être produite par une imprimante à couleurs pures ne pouvant imprimer que dans deux couleurs, comprenant :

des moyens pour exprimer la couleur pure et une couleur donnée de l'image polychrome dans des coordonnées de couleurs d'un système de coordonnées de couleurs YES déterminé par les formules suivantes :

$$Y \text{ (luminance)} = 0{,}253r + 0{,}684g + 0{,}063b \text{ ;}$$

$$E \text{ (échelle rouge-vert de la composante de chrominance)} = (r-g)/2 \text{ ;}$$

$$S \text{ (échelle jaune-bleu de la composante de chrominance)} = (r+g)/4 - b/2 \text{ ; et}$$

des moyens pour utiliser les coordonnées de couleurs de la couleur pure ($Y_hE_hS_h$) et de la couleur donnée ($Y_sE_sS_s$) pour projeter l'image polychrome sous la forme d'une image en couleurs pures ;
dans lequel des images d'illustration sont produites de façon que la proportion de couleur pure dans l'image projetée ne soit pas supérieure à celle qui est présente dans l'image polychrome.

15. Appareil selon la revendication 14, comprenant en outre :
des moyens pour déterminer les valeurs respectives des coordonnées rouge, verte et bleue (r,g,b) dans la couleur pure et la couleur donnée, chaque coordonnée (r,g,b) étant comprise entre 0 et 1.

16. Appareil selon la revendication 15, comprenant en outre :
des moyens pour projeter l'image polychrome sous la forme de l'image en couleurs pures en spécifiant les valeurs de la couleur pure (h), du blanc (w) et du noir (k) dans l'image en couleurs pures conformément à :

$$h = \mathrm{MAX}\,(0, (E_hE_s+S_hS_s)^3/((E_S{}^2+S_s{}^2)(E_h{}^2+S_h{}^2)^2))$$

$$w = \mathrm{MIN}(1-h, Y_s-hY_h)$$

$$k = 1-h-w.$$

**Patentansprüche**

1. Verfahren zum Abbilden eines Vollfarbenbildes auf ein durch einen Hervorhebungs-Farbdrucker (100), der nur zwei Farben drucken kann, erzeugbares Hervorhebungs-Farbbild, mit den Schritten:

Definieren eines im wesentlichen planaren Dreieck-Farbraumes (14), der einen vollständigen Satz von für den Hervorhebungs-Farbdrucker verfügbaren möglichen Farben umfaßt, welcher Dreieck-Farbraum zwischen zwei Punkten (18, 20), welche keine Farbe und eine vollgesättigte erste Hervorhebungsfarbe darstellen, definierte Basis (w) besitzt, und einen Scheitel (18), der einer vollgesättigten zweiten Hervorhebungsfarbe (h) des Hervorhebungs-Farbdruckers entspricht;
Bestimmen eines Ortes (24) einer vollgesattigten Farbe für einen bestimmten Farbton in dem Vollfarbenbild, innerhalb des Dreieck-Farbraumes; und
Abbilden eines Farbraumes für den bestimmten Farbton auf ein Dreieck (22) von durch den Hervorhebungs-Farbdrucker druckbaren Farben, wobei das Dreieck druckbarer Farben ein Teilsatz des Dreieck-Farbraumes ist und sein Scheitel (24) mit dem Ort der vollgesättigten Farbe des bestimmten Farbtons zusammenfällt.

2. Verfahren nach Anspruch 1, das weiter die Schritte umfaßt: Auswählen von Schwarz als der ersten Hervorhebungsfarbe; Auswählen von Rot als der zweiten Hervorhebungsfarbe; und Abbilden auf das Dreieck von druckbaren Farben durch:

a) Bestimmen der jeweiligen Ausmaße der Rot-, Grün- und Blau-Koordinaten (r,g,b) in dem Vollfarbenbild, wobei jede Koordinate sich zwischen 0 und 1 erstreckt, und

b) Bestimmen eines resultierenden Hervorhebungs-Farbbildes durch Spezifizieren der Ausmaße von Hervorhebungsfarbe (h), weiß (w) und schwarz (k) in dem Hervorhebungsfarbbild in Übereinstimmung mit:

$$h = (3MAX(r,g,b) + r - MAX(g,b) - 3MIN(r,g,b))/4,$$

$$w = (g - b + MAx(g,b) - MIN(r,g))/4 + MIN(r,g,b),$$

$$k = 1 - h - w.$$

3. Verfahren nach Anspruch 1, das weiter die Schritte umfaßt:

Erhalten der Luminanz des Vollfarbenbilds in dem abgebildeten Bild, wobei die Luminanz (y) bestimmt ist durch:

$$y = 1/4r + 2/3g + 1/12b;$$

wobei der Erhaltungsschritt das Abbilden auf das Dreieck von druckbaren Farben enthält durch:

a) Bestimmen der jeweiligen Ausmaße der Rot-, Grün- und Blau-Koordinaten (r,g,b) im Vollfarbenbild, von denen jede Koordinate sich zwischen 0 und 1 erstreckt, und
b) Bestimmen eines sich ergebenden abgebildeten Hervorhebungsfarbbilds durch Bestimmen der Hervorhebungsfarbe (h), weiß (w) und schwarz (k) in übereinstimmung mit:

$$h = MIN(4(MAX(r,g,b)-y)/3, 4(y-MIN(r,g,b)),r-MIN(r,g,b)),$$

$$w = y - h/4,$$

$$k = 1 - h - w.$$

4. Verfahren nach Anspruch 3, das weiter den Schritt umfaßt: Unterscheiden von vollgesättigten Farben in dem abgebildeten Bild durch Bestimmen des resultierenden abgebildeten Hervorhebungsfarbbilds durch Bestimmen durch h in Übereinstimmung mit:

$$h = MIN(4(MAX(r,g,b)-y)/3,4(y-MIN(r,g,b)),$$

$$r-MIN(r,g,b), (MAX(r,g,b) + r-b-MIN(r, g,b))/2,$$

$$MAX(r,g,b) - (8g + MIN(r,g,b))/9).$$

5. Verfahren zum Abbilden eines Vollfarbenbilds auf ein willkürliches durch einen Hervorhebungs-Farbdrucker, welcher in nur zwei Farben drucken kann, erzeugbares Hervorhebungsfarbbild, mit den Schritten:

Definieren eines im wesentlichen planaren Dreieck-Farbraumes, der einen vollständigen Satz von möglichen Farben für einen Hervorhebungs-Farbdrucker umfaßt, welcher Dreieck-Farbraum eine zwischen zwei Punkten (18, 20), welche keine Farbe und eine vollständig gesättigte erste Hervorhebungsfarbe repräsentieren, definierte Basis (w) besitzt und einen Scheitel (16) entsprechend der vollgesättigten zweiten Hervorhebungsfarbe (h) des Hervorhebungs-Farbdruckers; Bestimmen einer Ortskurve von vollgesättigten Farben in dem Farbraum;
Identifizieren des Farbtons der Hervorhebungsfarbe des Druckers;
Verschieben der vollgesättigten Farben um die Ortskurve, bis der Farbton an einer Extremstelle der Kurve

relativ zur Weiß/Schwarz-Achse dem Farbton der Hervorhebungsfarbe entspricht, und
Abbilden des Farbraumes in ein Dreieck von durch den Hervorhebungs-Farbdrucker druckbaren Farben für einen bestimmten Farbton, wobei das Dreieck ein Teilsatz des Farbraums ist und seinen Scheitel mit dem Ort einer vollgesättigten Farbe des bestimmten Farbtons zusammenfallend besitzt.

6. Verfahren zum Abbilden eines Vollfarbenbilds auf ein durch einen Hervorhebungs-Farbdrucker, der in nur zwei Farben drucken kann, erzeugbares Hervorhebungsfarbbild, mit den Schritten:

Ausdrücken der Hervorhebungsfarbe und einer bestimmten Farbe des Vollfarbenbilds in Farbkoordinaten eines YES-Farbkoordinatensystems, die bestimmt werden durch die folgenden Formeln:

$$Y\ (\text{Luminanz}) = 0{,}253r + 0{,}684g + 0{,}063b;$$

$$E\ (\text{Chrominanz-Komponente Rot/Grün-Skala}) = (r-g)/2;$$

$$S\ (\text{Chrominanz-Komponente Gelb/Blau-Skala}) = (r+g)/4 - b/2;\ \text{und}$$

Benutzen der Farbkoordinaten der Hervorhebungsfarbe ($Y_hE_hS_h$) und der bestimmten Farbe ($Y_sE_sS_s$) zum Abbilden des Vollfarbenbilds auf ein Hervorhebungsfarbbild;
wobei bildliche Darstellungen so erzeugt werden, daß nicht mehr Hervorhebungsfarbe in dem abgebildeten Bild als im Vollfarbenbild vorhanden ist.

7. Verfahren nach Anspruch 6, das weiter die Schritte umfaßt: Bestimmen der jeweiligen Ausmaße der Rot-, Grün- und Blau-Koordinaten (r,g,b) in der Hervorhebungsfarbe und der bestimmten Farbe, wobei sich jede Koordinate zwischen 0 und 1 erstreckt.

8. Verfahren nach Anspruch 7, das weiter den Schritt umfaßt: Abbilden des Vollfarbenbildes auf das Hervorhebungsfarbbild durch Spezifizieren der Ausmaße der Hervorhebungsfarbe (h), weiß (w) und schwarz (k) in dem Hervorhebungsfarbbild in Übereinstimmung mit:

$$h = MAX(0, (E_hE_s+S_hS_s)^3/((E_s^2+S_s^2)(E_h^2+S_h^2)^2)),$$

$$w = MIN(1 - h, Y_s - hY_h),$$

$$k = 1 - h - w.$$

9. Vorrichtung zum Abbilden eines Vollfarbenbildes auf ein durch einen Hervorhebungs-Farbdrucker, der in nur zwei Farben drucken kann, erzeugbares Hervorhebungsfarbbild, welche umfaßt:

Mittel zum Definieren eines im wesentlichen planaren Dreieck-Farbraumes, welcher einen vollständigen Satz von für einen Hervorhebungs-Farbdrucker möglichen Farben umfaßt, wobei der Dreieck-Farbraum eine zwischen zwei Punkten (18, 20), die keine Farbe und eine vollständig gesättigte erste Hervorhebungsfarbe darstellen, definierte Basis (w) besitzt und einen einer vollständig gesättigten zweiten Hervorhebungsfarbe (h) des Hervorhebungs-Farbdruckers entsprechenden Scheitel (16);
Mittel, um innerhalb des Dreieck-Farbraumes den Ort einer vollständig gesättigten Farbe für jeden bestimmten Farbton in dem Vollfarbenbild zu bestimmen, und
Mittel zum Abbilden des Farbraumes für den gegebenen Farbton auf ein Dreieck von durch den Hervorhebungs-Farbdrucker druckbaren Farben, wobei das Dreieck ein Teilsatz des Farbraumes ist und seinen Scheitel mit dem Ort der vollständig gesättigten Farbe des bestimmten Farbtones zusammenfallend besitzt.

10. Vorrichtung nach Anspruch 9, welche weiter umfaßt:

Mittel zum Bezeichnen von rot als der Hervorhebungsfarbe; und
wobei das Abbildungsmittel enthält:

a) Mittel zum Bestimmen der jeweiligen Ausmaße der Rot-, Grün- und Blau-Koordinaten (r,g,b) in dem Vollfarbenbild, wobei sich jede Koordinate zwischen 0 und 1 erstreckt; und
b) Mittel zum Bestimmen eines resultierenden Hervorhebungfarbbildes durch Angeben der Ausmaße von Hervorhebungfarbe (h), weiß (w) und schwarz (k) in dem Hervorhebungfarbbild in Übereinstimmung mit:

$$h = (3MAX(r,g,b) + r - MAX(g,b) - 3MIN(r,g,b))/4,$$

$$w = (g - b + MAX(g,b) - MIN(r,g))/4 + MIN(r,g,b)$$

$$k = 1 - h - w.$$

11. Vorrichtung nach Anspruch 9, die weiter umfaßt:

Mittel zum Erhalten der Luminanz des Vollfarbenbilds in dem abgebildeten Bild, wobei die Luminanz (y) bestimmt wird durch:

$$y = 1/4r + 2/3g + 1/12b;$$

das Erhaltungsmittel enthält:

a) Mittel zum Bestimmen der jeweiligen Ausmaße der Rot-, Grün- und Blau-Koordinaten (r,g,b) in dem Vollfarbenbild, wobei jede Koordinate von 0 bis 1 reicht; und
b) Mittel zum Bestimmen eines resultierenden abgebildeten Hervorhebungfarbbilds durch Bestimmen von Hervorhebungfarbe (h), weiß (w) und schwarz (k) in Übereinstimmung mit:

$$h = MIN(4(MAX(r,g,b)-y)3,4(y-MIN(r,g,b)),r-MIN(r,g,b)),$$

$$w = y - h/4,$$

$$k = 1 - h - w.$$

12. Vorrichtung nach Anspruch 11, die weiter umfaßt:
Mittel zum Unterscheiden vollgesättigter Farben in dem abgebildeten Bild durch Bestimmen des resultierenden abgebildeten Hervorhebungfarbbilds durch Bestimmen von h in Übereinstimmung mit:

$$h = MIN(4(MAX(r,g,b)-y)/3,4(y-MIN(r,g,b)),$$

$$r-MIN(r,g,b),(MAX(r,g,b) + r-b-MIN(r,g,b))/2,$$

$$MAX(r,g,b) - (8g + MIN(r, g,b))/9).$$

13. Vorrichtung zum Abbilden eines Vollfarbenbildes auf ein mit einem Hervorhebungs-Farbdrucker, der nur in zwei Farben drucken kann, erzeugbares willkürliches Hervorhebungsfarbbild, welche umfaßt:

erstes Mittel zum Definieren eines im wesentlichen planaren Dreieck-Farbraumes, der einen vollständigen Satz von für einen Hervorhebungs-Farbdrucker möglichen Farben umfaßt, wobei der Dreieck-Farbraum eine zwischen zwei keine Farbe und eine vollständig gesättigte erste Hervorhebungsfarbe darstellenden Punkten

(18, 20) definierte Basis (w) besitzt und einen einer vollständig gesättigten zweiten Hervorhebungsfarbe (h) des Hervorhebungs-Farbdruckers entsprechenden Scheitel (16);
zweites Mittel, um in dem Farbraum eine Ortskurve von vollgesättigten Farben zu definieren;
Mittel zum Identifizieren des Farbtons der Hervorhebungsfarbe des Druckers;
Mittel zum Verschieben der vollgesättigten Farben um die Ortskurve, bis der Farbton an einer extremen Stelle der Kurve, abgelegen von der Schwarz/Weiß-Achse, dem Farbton der Hervorhebungsfarbe entspricht, und
Mittel zum Abbilden des Farbraumes für einen bestimmten Farbton in ein Dreieck von durch den Hervorhebungs-Farbdrucker druckbaren Farben, wobei das Dreieck ein Teilsatz des Farbraumes ist und seinen Scheitel mit dem Ort einer vollgesättigten Farbe des bestimmten Farbtons zusammenfallend besitzt.

**14.** Vorrichtung zum Abbilden eines Vollfarbenbilds auf ein durch einen Hervorhebungs-Farbdrucker, der in nur zwei Farben drucken kann, erzeugbares Hervorhebungsfarbbild, welche umfaßt:

Mittel zum Ausdrücken der Hervorhebungsfarbe und einer bestimmten Farbe des Vollfarbenbilds in Farbkoordinaten eines YES-Farbkoordinatensystems, das bestimmt ist durch die folgenden Formeln:

$$Y\ (\text{Luminanz}) = 0{,}253r + 0{,}684g + 0{,}063b;$$

$$E\ (\text{Chrominanz-Komponente Rot/Grün-Skala}) = (r-g)/2;$$

$$S\ (\text{Chrominanz-Komponente Gelb/Blau-Skala}) = (r + g)4 - b/2;\ \text{und}$$

Mittel zum Verwenden der Farbkoordinaten der Hervorhebungsfarbe ($Y_hE_hS_h$) und der bestimmten Farbe ($Y_sE_sS_s$) zum Abbilden des Vollfarbenbilds auf ein Hervorhebungsfarbbild;
wobei bildliche Darstellungen so erzeugt werden, daß nicht mehr Hervorhebungsfarbe in dem abgebildeten Bild als im Vollfarbenbild vorhanden ist.

**15.** Vorrichtung nach Anspruch 14, die weiter umfaßt: Mittel zum Bestimmen der jeweiligen Ausmaße der Rot-, Grün- und Blau-Koordinaten (r,g,b) in der Hervorhebungsfarbe und der bestimmten Farbe, wobei jede Koordinate (r,g, b) sich von 0 bis 1 erstreckt.

**16.** Vorrichtung nach Anspruch 15, die weiter umfaßt:
Mittel zum Abbilden des Vollfarbenbilds auf das Hervorhebungsfarbbild durch Benennen der Größen von Hervorhebungsfarbe (h), weiß (w) und schwarz (k) in dem Hervorhebungsfarbbild in Übereinstimmung mit:

$$h = \mathrm{MAX}(0, (E_hE_s+S_hS_s)^3 / ((E_s^2+S_s^2)\ (E_h^2+S_h^2)^2))$$

$$w = \mathrm{MIN}(1 - h, Y_s - hY_h)$$

$$k = 1 - h - w.$$

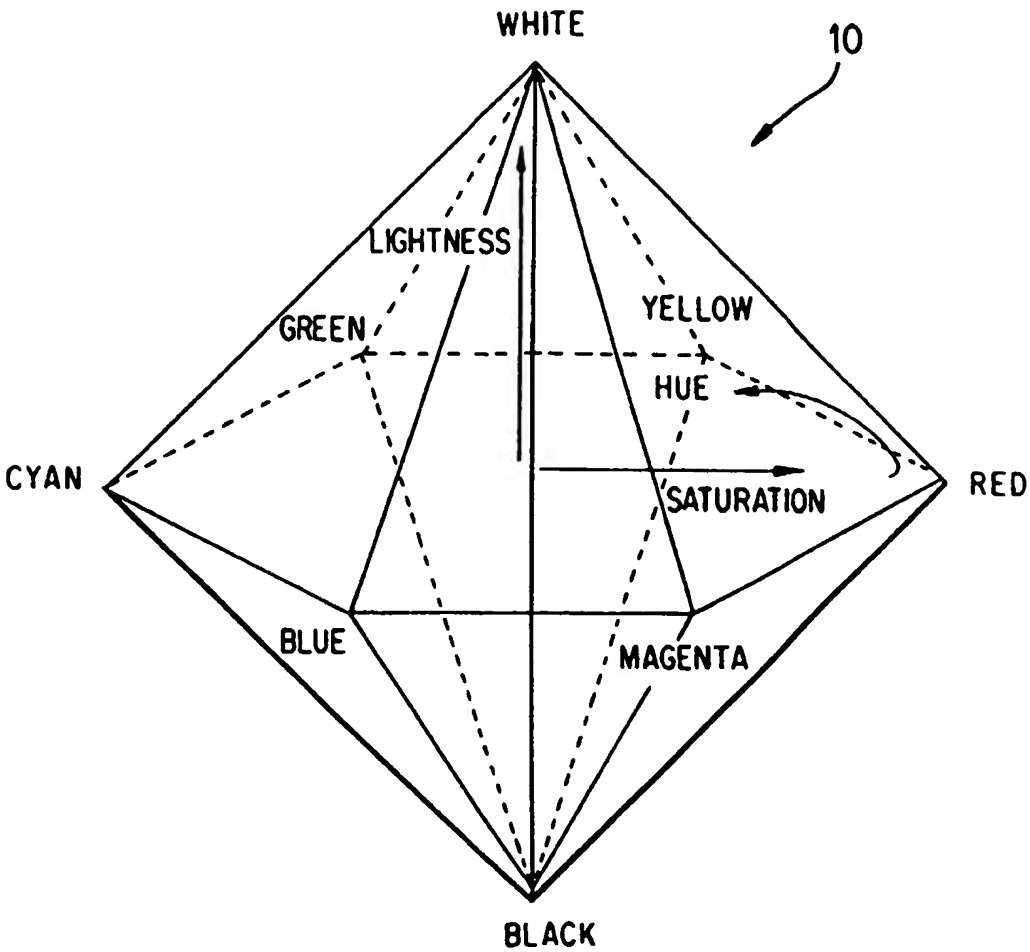
WHITE
10
LIGHTNESS
GREEN
YELLOW
HUE
CYAN
SATURATION
RED
BLUE
MAGENTA
BLACK

FIG. 1

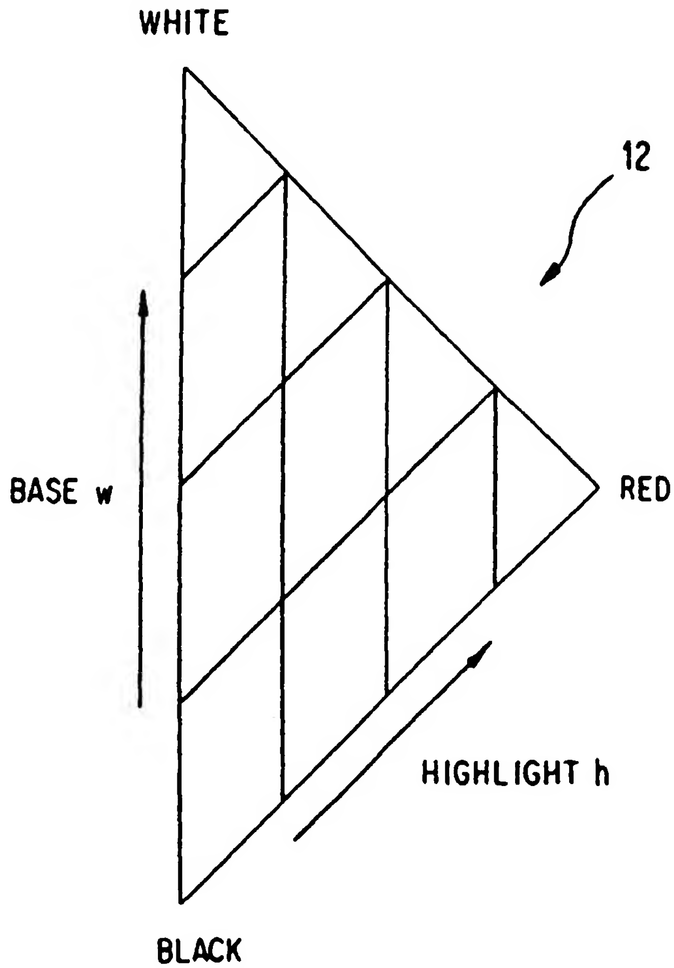


FIG. 2

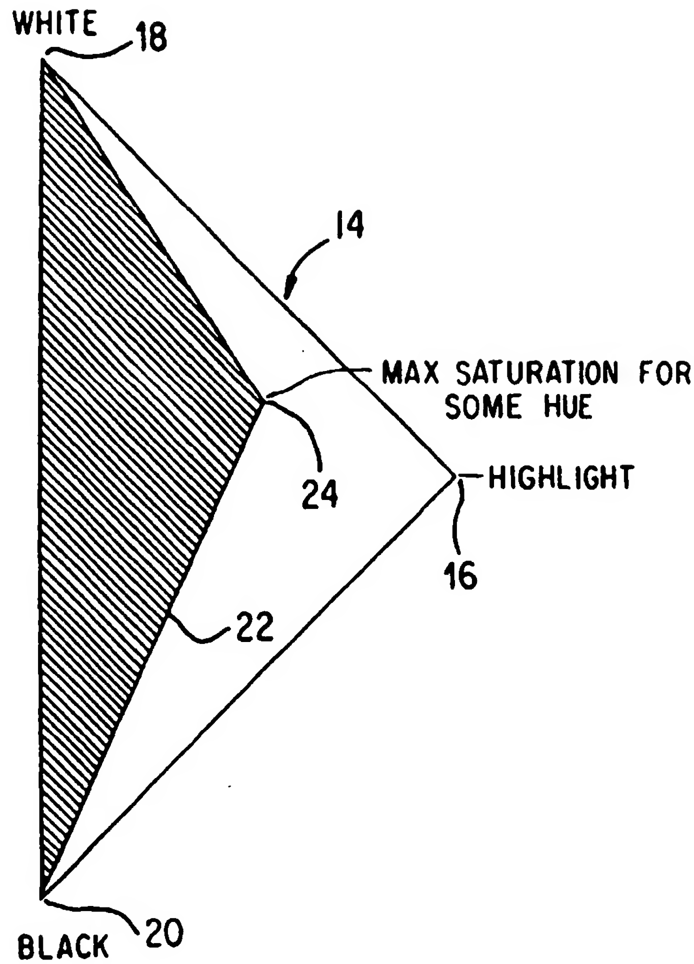
WHITE
18
14
MAX SATURATION FOR
SOME HUE
24
HIGHLIGHT
16
22
BLACK
20

FIG. 3

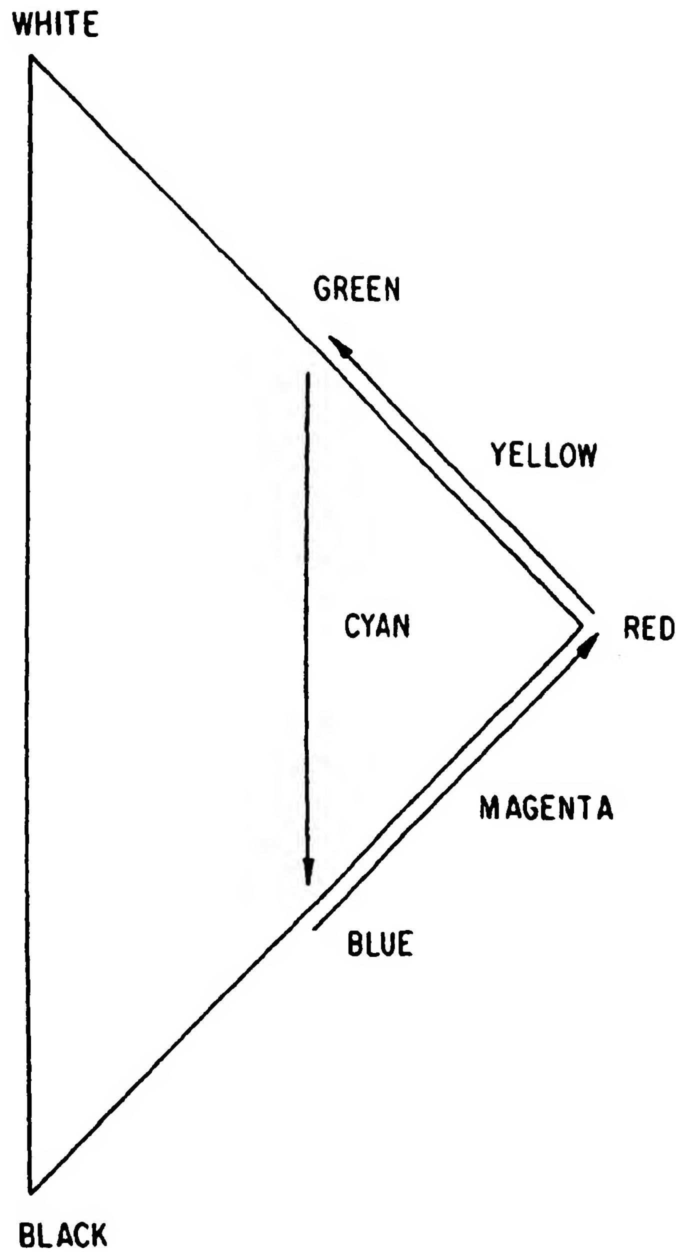


FIG. 4

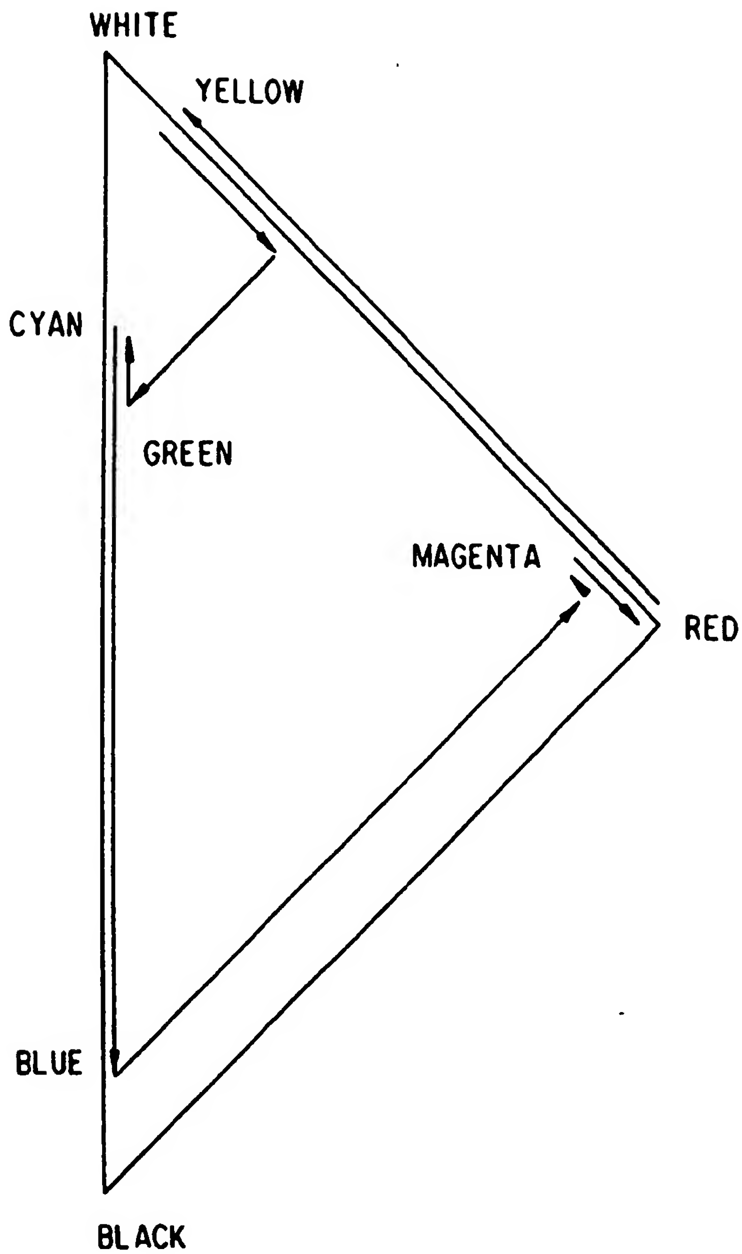


FIG. 5

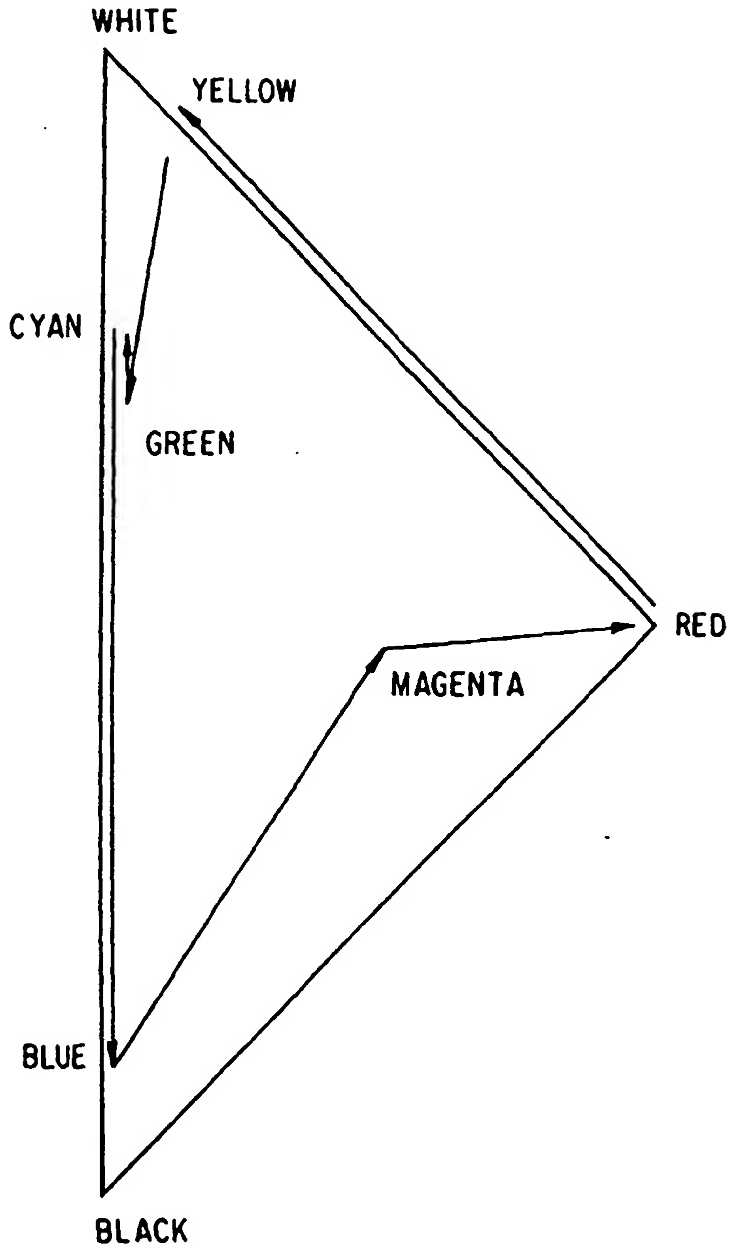


FIG. 6

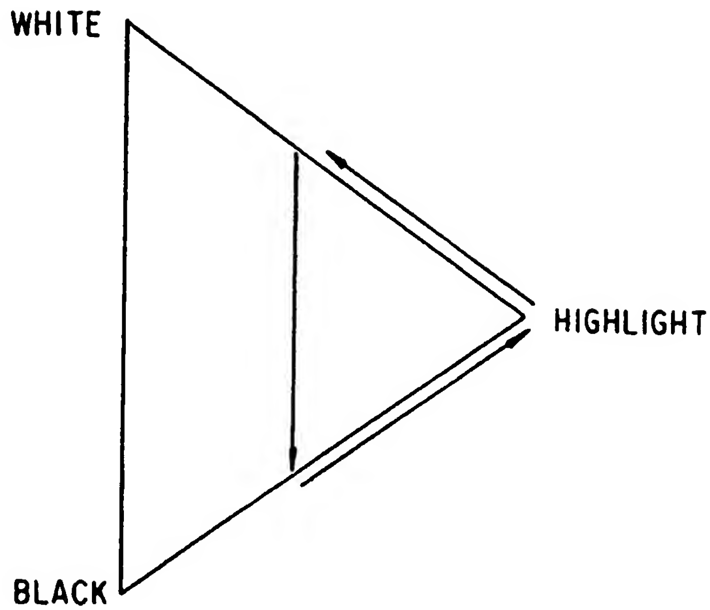


FIG. 7

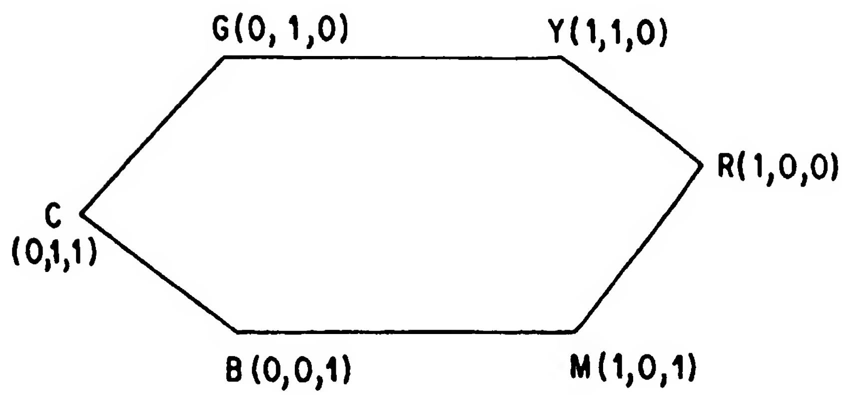


FIG. 8

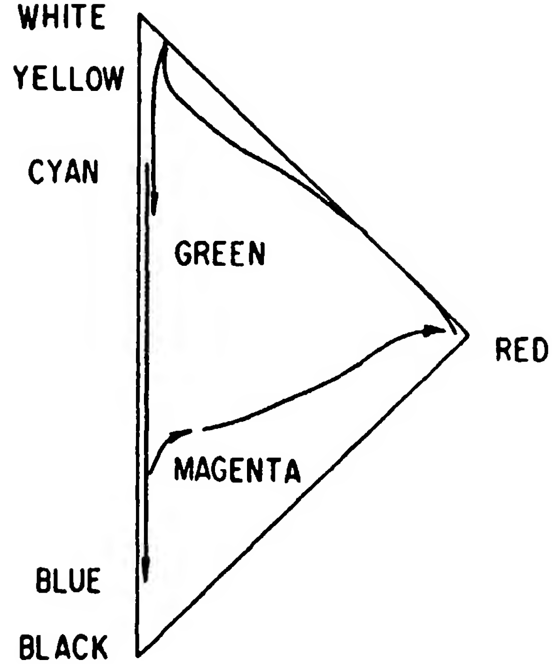
WHITE
YELLOW
CYAN
GREEN
RED
MAGENTA
BLUE
BLACK

FIG. 9

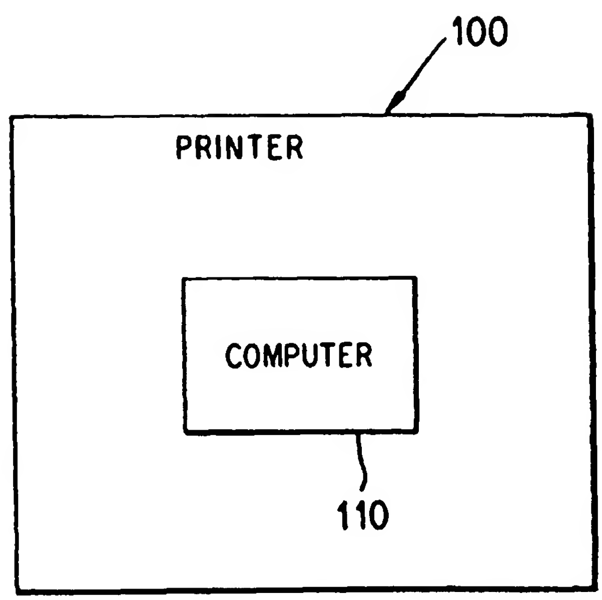
100
PRINTER
COMPUTER
110

FIG. 10